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Gregory Tsoucalas, Antonis A. Kousoulis, Theodoros Mariolis-Sapsakos, Markos Sgantzos



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**Historical vignette****Trepanation practices in Asclepieia: systematizing a neurosurgical innovation**

Gregory Tsoucalas<sup>1</sup>, Antonis A. Kousoulis<sup>2</sup>, Theodoros Mariolis-Sapsakos<sup>3</sup>, Markos Sgantzos<sup>1,4</sup>.

1. *History of Medicine, Faculty of Medicine, University of Thessaly, Larissa, Greece.*
2. *Faculty of Epidemiology and Public Health, London School of Hygiene & Tropical Medicine, London, UK.*
3. *Laboratory of Anatomy, School of Nursing, National and Kapodistrian University of Athens, Athens, Greece.*
4. *Department of Anatomy, Faculty of Medicine, University of Thessaly, Larissa, Greece.*

**Highest academic degrees:** Gregory Tsoucalas, MD, PhD, Theodoros Mariolis-Sapsakos MD, Prof, and Markos Sgantzos, MD, Prof.

**Corresponding Author:** Gregory Tsoucalas, Ieroloxiton 155, Agioi Anargyroi, Volos, P.C. 38334, Greece. Email: gregorytsoucalas@yahoo.gr

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**Abbreviations list:** ca: circa, approximately; BC: Before Christ

**Abstract**

As ancient Greeks started looking for deities that could fulfil the pragmatic needs of common people, local heroes started being mythologized and worshipped through cults. The most widespread such example was Asclepius, possibly a skilled war surgeon who followed military expeditions to Colchis and Troy. He was worshipped at religious temples called Asclepieia where certain specific medical and surgical techniques were followed. The most advanced must have been skull trepanation, most likely done as an acute operation to release intracranial pressure. The contemporary Hippocratic corpus provided extensive descriptions of the technique and archaeological evidence have shown that many patients survived the operation. Decompressive craniectomy techniques have been practiced for millennia but it is possible that they were first systematized as a neurosurgical innovation through the Ancient Greek religious cult followed in Asclepieia

## Background

As Ancient Greece developed around several big administrative centres, a variety of political systems and social structures were constantly being tested with the aim of providing citizens with a sense of local community. This evolution in the structure of Greek cities gradually led to citizens looking for new ways to practice their religion. The major deities, the Olympian gods, distant and traditional, could no longer fulfil the pragmatic needs of common people, and gradually took a secondary role in everyday religious practice. This context nurtured a new subculture of beliefs in which local heroes would acquire divine status and be worshiped through cults. The myth of Asclepius is the most representative example of that trend, and as with all mythologies, critical examination of texts derived from that era can serve as educational insight to local knowledge and beliefs, including medical practice.<sup>1</sup> The cult of Asclepius, as reflected through its rife healing temples, Asclepieia, remained active possibly for almost two thousand years, marking an important chapter in the global history of medicine.

The people worshipping Asclepius were expressing a need for a special god-healer, including in palliative care, who would deliver against the fear of death. Medical practice was, at the time, closely linked to religious practice which moved from the worship of local gods-therapists across Greece, to national practice under the patronage of god Asclepius (ca 13th century BC).<sup>2,3</sup> The popularity of Asclepius and his sacred snake meant that people flocked the temples hoping for miraculous remedies to a huge range of conditions. In his temples, various therapeutic practices were followed, including religious sacrifices, purifying baths, hydrotherapy, fasts,

gymnastic exercises, massage, strengthening of the psyche, sleep therapy, hypnotism, fortune telling, spiritual exorcisms, therapeutic touch, as well as detailed body examinations, minor surgical procedures and distribution of herbal medicines.<sup>4</sup> Asclepius, as a probable historical person, might have been a skilled war surgeon who practiced his techniques around ancient Greece, possibly also joining legendary war trips, like the argonauts' quest to Colchis and the Trojan war.<sup>5-6</sup> He became an accessible symbol for common people's beliefs who were celebrating a war hero and a healing god whose human nature was intertwined with that of his serpent.<sup>7</sup>

### **Trepanning in Asclepieia**

Possibly the most advanced and difficult surgical procedure practiced in the Asclepieia was trepanation (a word originating from the Greek word "trepani", drill). There are strong archaeological evidence today showing that certain patients survived the seemingly barbaric operation, largely undertaken using metal tools.<sup>8</sup> Initially performed to exorcise evil spirits (what would today be associated with psychosis or other mental illness), it evolved over the centuries and remained an orthodox surgical intervention aiming at curing a number of brain and neuro-psychiatric conditions.

In the Hippocratic Corpus, the most comprehensive knowledge base of the era, brain damage was described as an excessive imbalance of the 4 body humours. Any cranial or brain trauma was to be treated as an acute condition. Trepanation was recommended in the cases of cranial fracture (either domestic accidents or battle wounds), periosteal stripping, massive intracranial haemorrhage, apoplexy (as a cluster of acute brain conditions), epilepsy (or any continuous spasms), "acute brain

anguish" (possibly stroke). The operation was performed both in adult and younger patients. A slow drilling of the cranial bones would follow a thorough examination of the whole cranium with the use of a metallic probe (Greek: μήλη), with the eventual aim of brain decompression. According to these texts:

*"The bones should be perforated until the edge of the diploic layer, while the meninges should be left intact. During the drilling the physician should often pull the drill (Greek: πρίων) out to the skull - as it may warm the bones up too much - and dip it into cold water. The drill may be heated by the constant rotation, warming and drying the bone, and burning it and causing the adjacent bone necrosis (greater than it would have been without the extreme heat). If someone wants to drill and immediately remove a bone fragment from the dura mater, he should also take the drill out many times and dip it in cold water. The surgical wound should be cauterized and a poultice should be applied to cover the cranial gap. Cathartics for the reduction of the visceral fluid volume should be administered, along with tranquilizers (mulberries, honey and vinegar, valerian, lavandula) and sedatives (mandragoras, opium, ervum ervillia)".<sup>9</sup>*

Other than the practice that was followed in the Asclepieia as above, trepanations have also been attributed to Asclepius himself most possibly to treat serious battle wounds.<sup>7</sup> He would have performed cranial trepanations to treat men with symptoms like ataxia, alexia, high fever, spasms, excessive vomiting, hyper salivation, mania, disequilibrium, and coma.<sup>10</sup>

## **Conclusion**

In the event that Asclepius' himself was a historical figure practicing war surgery, as we are mostly led to believe by contemporary sources, he would not have the time or means to record the methods to his procedures in detail. Thus, the best source for the Asclepieian practice is the Hippocratic corpus, given that Hippocrates studied and practiced medicine largely in the Asclepieion of Kos. He must have systematized the procedure, which was already practiced before his time by war surgeons and local practitioners. Decompressive craniectomy techniques have been practiced for millennia but it is possible that they were first systematized as a neurosurgical innovation through the Ancient Greek religious cult followed in Asclepieia.

**References**

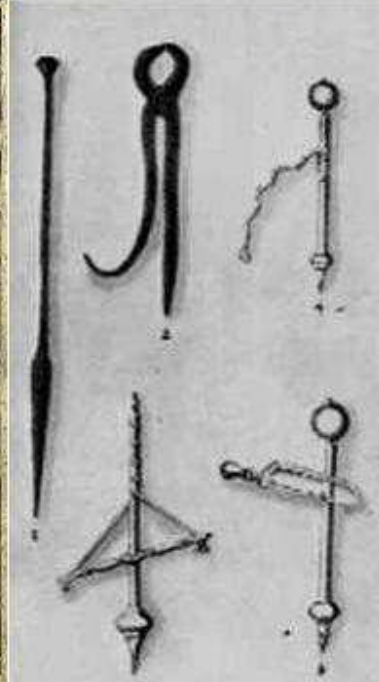
1. Kousoulis AA, Mylonas KS, Economopoulos KP. Violent death and trauma in Norse mythology: a systematic reading of the Prose Edda. *European Surgery* 2016;48(5):304-10.
2. Neumann G. *Probleme des griechischen Weihreliefs, Tübinger Studien zur Archäologie und Kunst Geschichte, III*. Berlin, Germany: Ernst Wasmuth Verlag; 1978: 51.
3. Constantelos D. The interface of Medicine and Religion in the Greek and the Christian Greek Orthodox tradition. *Greek Orthodox Theological Review* 1988;33: 1-17.
4. Tsoucalas G, Karamanou M, Laios K, Sgantzios M, Androutsos G. The Forgotten Asclepieion of Peparithos and the Islander Worshippers of the Snake God. *J Relig Health* 2016;55(1): 43-49.
5. Apollodorus. *Apollodori Bibliotheca*. Leipzig, Germany : Bekker, 1854: B3 120.
6. Diodorus. *The Historical Library of Diodorus the Sicilian: In Fifteen Books*. London, England: WM Dowall, 1814: B5 74, 6.



7. Tsoucalas G, Sgantzios M. *History of Toxicology and Environmental Health, Asclepius and the Snake as Toxicological Symbols in ancient Greece and Rome*. Oxford, USA: Elsevier; 2015.
8. Papagrigorakis MJ, Toulas P, Tsilivakos MG, Kousoulis AA, Skorda D, Orfanidis G, Synodinos PN. Neurosurgery during the Bronze Age: a skull trepanation in 1900 BC Greece. *World Neurosurg*. 2014;81(2): 431-435.
9. Hippocrates. *De morbis popularibus [Επιδημίες] & Des fractures [Περί των εν Κεφαλή Τρωμάτων]*, ed. É. Littré, Oeuvres complètes d'Hippocrate, vols 5 & 3. Paris, France: Baillière; 3: 1841, 5:1846 (repr. Amsterdam: Hakkert, 3:1961; 5:1962), (Cod: 43,404: Med.).
10. Hemmeter JC. *Master Minds in Medicine: An Analysis of Human Genius as the Instrument in the Evolution of Great Constructive Ideas in the History of Medicine, Together with a System of Historic Methodology*. New York, USA: Medical life Press; 1927.

**Figure legend**

**Figure 1:** Asclepius, from the marble statue in the Louvre, engraving by Jenkins, London ca 1860, and a neolithic trepanned skull, Ukraine (top side). Hippocrates, wood engraving, 16th century, and ancient Greek trephines, illustration in a manuscript by Vidus, 1544 (bottom side).



**Highlights of the manuscript titled: Asclepius's open brain drilling, a divine barbaric method in the eve of neurosurgery**

Original historical research tracing the eve of brain surgery.

The manuscript depict the social status of the era that contributed to Asclepius ascendance as a god.

The cranial trepanism is described as it was firstly written in Corpus Hippocraticum by Hippocrates and His followers.

The myth of Asclepius is somehow decoded for a reality to be presented.

Asclepius presented as a war-surgeon, able to perform brutal surgical techniques. A rather original approach of his myth.